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AF/2624 12/12/03

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Robert D. Barnes et al.	§		
	§	Group Art Unit:	2624
Serial No.: 09/448,940	§		
Filed: November 24, 1999	§	Examiner:	Do, Anh Hong
	§		
For: IMAGE DATA COMPRESSION EMPLOYING MULTIPLE COMPRESSION CODE TABLES	§	Atty. Docket:	GEMS:0071/YOD 15-IS-5393

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37 C.F.R. 1.8

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December 1, 2003	
Date	Tait R. Swanson

APPEAL BRIEF PURSUANT TO 37 C.F.R. §§ 1.191 AND 1.192

This Appeal Brief is being filed in furtherance to the Notice of Appeal mailed on August 25, 2003, and received by the Patent Office on August 29, 2003.

1. REAL PARTY IN INTEREST

The real party in interest is General Electric Company, the Assignee of the above-referenced application by virtue of the Assignment recorded at reel 010421, frame 0753, and recorded on November 24, 1999. General Electric Company, the Assignee of the above-referenced application, as evidenced by the documents mentioned above, will be directly affected by the Board's decision in the pending appeal.

2. RELATED APPEALS AND INTERFERENCES

Appellants are unaware of any other appeals or interferences related to this Appeal. The undersigned is Appellants' legal representative in this Appeal.

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3. STATUS OF CLAIMS

Claims 1-27 are currently pending, and claims 1-27 are currently under final rejection and, thus, are the subject of this appeal.

4. STATUS OF AMENDMENTS

The Appellant has not submitted any amendments subsequent to the Final Office Action mailed on May 20, 2003.

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5. SUMMARY OF THE INVENTION AND OF THE DISCLOSED EMBODIMENTS

Various techniques have been proposed and are currently in use for analyzing and compressing large data files, such as image data files. *See* Application, Background, Page 1, lines 11-12. Image data files typically include streams of data descriptive of image characteristics, typically of intensities or other characteristics of individual pixel elements or pixels in a reconstructed image. *See id.* at lines 12-15. In the medical field, for example, large image files are typically created during an image acquisition or encoding sequence, such as in an x-ray system, a magnetic resonance imaging system, a computed tomography imaging system, and so forth. *See id.* at lines 15-18. The image data is then processed, such as to adjust dynamic ranges, enhance certain features shown in the image, and so forth, for storage, transmittal and display. *See id.* at lines 18-20.

While image files may be stored in raw and processed formats, many image files are quite large, and would occupy considerable memory space. *See id.* at lines 22-23. The increasing complexity of imaging systems also has led to the creation of very large image files, typically including more data as a result of the useful dynamic range of the imaging system and the size of the matrix of image pixels. *See id.* at lines 23-26.

In addition to occupying large segments of available memory, large image files can be difficult or time consuming to transmit from one location to another. *See id.* at lines 28-29. For example, in a typical medical imaging application, a scanner or other imaging device typically creates raw data, which may be transmitted to one or more other locations for processing. *See id.* at Page 1, line 29 – Page 2, line 6. Thus, the large size of these raw data files significantly slows the data transfer rates. *See id.*

Compression techniques have been developed that apply various algorithms and approaches to conversion of original image data to a compressed form for transmission and storage. *See id.* at Page 2, lines 8-10. One such approach is based upon assignment of compressed data code by reference to a table, commonly referred to as a compression table. *See id.* at lines 10-12. This approach is based on the probability (or the frequency) of occurrence of different levels, typically gray levels or intensity levels, for each pixel in an image, represented by corresponding binary values in the image data stream. *See id.* at lines 12-14. In general, compression code table permits more frequently occurring values to be assigned a shorter compressed data code than less frequently occurring values. *See id.* at lines 15-16. Compression ratios in such techniques may, however, be highly dependent upon the relative frequencies of occurrence of the values across the dynamic range of the image data. *See id.* at lines 17-19.

The subject matter disclosed and claimed in the present application addresses provides a computationally efficient technique for compressing and decompressing image data with higher relative compression ratios. *See id.* at lines 21-25. Specifically, the

6. **ISSUES**

Issue No. 1:

Whether claims 1 and 24-27 are unpatentable under 35 U.S.C. 102(e) as anticipated by Hirabayashi et al., U.S. Patent No. 6,101,282 (hereinafter "Hirabayashi" or "the Hirabayashi reference").

Issue No. 2:

Whether claims 18-23 are unpatentable under 35 U.S.C. 102(e) as anticipated by Puri, U.S. Patent No. 5,563,593 (hereinafter "Puri" or "the Puri reference").

Issue No. 3:

Whether claims 2-17 are unpatentable under 35 U.S.C. 103(a) as obvious over Hirabayashi in view of Puri.

7. **GROUPING OF CLAIMS**

Group I:	Independent claim 1 and dependent claims 2-11 will stand or fall together.
Group II:	Independent claim 12 and dependent claims 13-17 will stand or fall together.
Group III:	Independent claim 18 and dependent claims 19-23 will stand or fall together.
Group IV:	Independent claim 24 and dependent claims 25-27 will stand or fall together.

8. **ARGUMENT**

Issue No. 1

In the Final Office Action, the Examiner rejected independent claims 1 and 24 and dependent claims 23-27 under 35 U.S.C. 102(e) as anticipated by the Hirabayashi reference. Appellants traverse these rejections and request the Board withdraw the outstanding rejections for the reasons set forth below the following legal precedent.

Legal Precedent

First, anticipation under section 102 can be found only if a single reference shows exactly what is claimed. *Titanium Metals Corp. v. Banner*, 778 F.2d 775, 227 U.S.P.Q. 773 (Fed. Cir. 1985). For a prior art reference to anticipate under section 102, every element of the claimed invention must be identically shown in a

single reference. *In re Bond*, 910 F.2d 831, 15 U.S.P.Q.2d 1566 (Fed. Cir. 1990). To maintain a proper rejection under section 102, a single reference must teach each and every limitation of the rejected claim. *Atlas Powder v. E.I. du Pont*, 750 F.2d 1569 (Fed. Cir. 1984). Accordingly, the Appellants need only point to a single element not found in the cited reference to demonstrate that the cited reference fails to anticipate the claimed subject matter. The prior art reference also must show the *identical* invention "*in as complete detail as contained in the ... claim*" to support a *prima facie* case of anticipation. *Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 1236, 9 U.S.P.Q. 2d 1913, 1920 (Fed. Cir. 1989).

Second, regarding claim interpretation, the claims must be given their broadest reasonable interpretation consistent with the specification. *See In re Prater*, 415 F.2d 1393, 1404-05, 162 U.S.P.Q. 541, 550-51 (C.C.P.A. 1969); *see also In re Morris,* 127 F.3d 1048, 1054-55, 44 U.S.P.Q.2d 1023, 1027-28 (Fed. Cir. 1997); *see also* M.P.E.P. §§ 608.01(o) and 2111. Interpretation of the claims must also be consistent with the interpretation that those skilled in the art would reach. *See In re Cortright*, 165 F.3d 1353, 1359, 49 U.S.P.Q.2d 1464, 1468 (Fed. Cir. 1999); *see also* M.P.E.P. § 2111. As further explained in Section 2111.01 of the M.P.E.P., the words of the claim must be given their plain meaning unless the applicant has provided a clear definition in the specification. *See In re Zletz*, 893 F.2d 319, 321, 13 U.S.P.Q.2d 1320, 1322 (Fed. Cir. 1989). Again, the plain meaning refers to an interpretation by those of ordinary skill in the art. *See In re Sneed,* 710 F.2d 1544, 218 U.S.P.Q. 385 (Fed. Cir. 1983).

Third, regarding the theory of inherency, the extrinsic evidence must make clear that the missing descriptive matter is *necessarily* present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. *In re Robertson,* 169 F.3d 743, 49 U.S.P.Q.2d 1949 (Fed. Cir. 1999) (Emphasis Added). The mere fact that a certain thing *may* result from a given set of circumstances is not sufficient. *Id.* In relying upon the theory of inherency, the Examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic *necessarily* flows from the teachings of the applied prior art. *Ex parte Levy,* 17 U.S.P.Q.2d 1461, 1464 (Bd. Pat. App. & Inter. 1990) (emphasis in original). The Examiner, in presenting the inherency argument, bears the evidentiary burden and must adequately satisfy this burden. *See id.* Regarding functional limitations, the Examiner must evaluate and consider the functional limitation, just like any other limitation of the claim, for what it fairly conveys to a person of ordinary skill in the pertinent art in the context in which it is used. *See* M.P.E.P. § 2173.05(g); *In re Swinehart*, 169 U.S.P.Q. 226, 229 (C.C.P.A. 1971); *In re Schreiber*, 44 U.S.P.Q.2d 1429, 1432 (Fed. Cir. 1997). If the Examiner believes the functional limitation to be inherent in the cited reference, then the Examiner "must provide some evidence or scientific reasoning to establish the reasonableness of the examiner's

belief that the functional limitation is an inherent characteristic of the prior art." *Ex parte Skinner,* 2 U.S.P.Q.2d 1788, 1789 (Bd. Pat. App. & Inter. 1986).

Fourth, the *drawings* of the cited reference must be evaluated for what they *reasonably disclose and suggest* to one of ordinary skill in the art. *In re Aslanian*, 590 F.2d 911, 200 U.S.P.Q. 500 (CCPA 1979).

GROUP I: Independent Claim 1

Claims

In view of the foregoing legal precedent and summary of problems and solutions provided by the present application, independent claim 1 recites:

> A method for compressing image data from an uncompressed image data stream, the method comprising the steps of:
> (a) compiling and storing a plurality of compression mapping tables for converting uncompressed data representative of individual picture elements to *lossless compressed data*;
> (b) *applying at least first and second compression mapping tables* from the stored plurality of compression mapping tables *to subregions* of an uncompressed image data stream to compress the subregions; and
> (c) appending data for the compressed subregions to form a compressed image data stream.

As set forth above, claim 1 is clearly directed toward *lossless data compression* using at least *first and second compression mapping tables* to compress subregions of an *uncompressed* image data stream. In context of the claim as a whole, the first and second compression mapping tables are clearly applied to the different *subregions* (not the entire image) of the *uncompressed* image data stream (not compressed or partially compressed). Accordingly, these first and second compression mapping tables are *not merely applied one after the other* (i.e., in series), because the foregoing claim recites that the first and second compression mapping tables are *both applied* to subregions of an *uncompressed* image data stream. Moreover, the first and second compression mapping tables are not merely used to evaluate differences in an image (i.e., pixel to pixel variances), because the foregoing claim recites that the tables are both applied to *compress the subregions*. Clearly, the claim recites that *both of the first and second compression mapping tables* apply to the subregions of uncompressed image data stream for lossless data compression.

Appellants also emphasize that the claim features, including the first and second compression tables and subregions of uncompressed image data, must be interpreted reasonably and consistently within the scope of the specification and within the understanding of one of ordinary skill in the art. *See In re Prater*, 415 F.2d 1393, 1404-05 (C.C.P.A. 1969). The broadest reasonable and consistent interpretation that one of ordinary skill in the

art might adopt would not ignore the terms *subregions of an uncompressed image data stream*, much less the *first and second* compression tables applied to those subregions for *lossless* data compression.

For these reasons, Appellants stress that claim 1 cannot be anticipated absent a disclosure of *at least two* compression mapping tables applied to *subregions* of an *uncompressed* image data stream for compression of those subregions.

Omitted Features

Appellants respectfully assert that the Hirabayashi reference does not disclose all of the claimed features, such as the application of first and second compression mapping tables to subregions of uncompressed image data. However, in the Final Office Action, the Examiner argued that the cited reference, at col. 8, lines 1-4, discloses at least two compression tables applied to pixel blocks of uncompressed data. *See* Paper 7, Page 5. Appellants respectfully traverse these rejections.

As emphasized previously, the cited reference absolutely fails to teach or even suggest the use of multiple code tables *for actually encoding an overall image*, much less encoding the overall image by applying first and second tables to subregions of uncompressed image data. Rather, multiple tables are employed by Hirabayashi et al. as <u>*starting points for evaluating*</u> to what level an image should be subdivided for optimal compression. *See* Hirabayashi, Col. 9, lines 7-59.

Referring specifically to the reference, several variants of a basic compression method are described. In the first, and more generic form, sets of reference Huffman tables are starting points for a compression of blocks of different sizes, such as from 4-pixel square blocks to 128-pixel square blocks. The procedure proceeds through the subdivision of an image into these various block sizes. Code tables are then applied to the blocks to determine statistics relating to the compression characteristics obtainable through both the block division and the use of the compression tables. The tables are, in fact, redefined in real time during the process, with the reference tables merely serving as starting points for the eventual encoding that will take place. *See* Hirabayashi Col. 7, lines 38-57.

However, the foregoing code tables never serve, together or alone, for encoding the actual image. Rather, one reading the reference would most reasonably conclude that a <u>*single table*</u> is ultimately selected for encoding the various blocks, with the candidate tables merely serving as options for the eventual encoding, in connection with the appropriate selection of the block sizes. *See* Hirabayashi Col. 9, lines 54-59.

In column 8, lines 13-16 of the reference, for example, reference is made to Figure 10 which is said to represent a train of encoded data resulting from the process. As clearly seen in Figure 10, the entire image, referred to in the figure as "one image" includes optimal Huffman table data as a first portion of the string, followed by reference information, which itself includes the block division information and the encode method. It should be noted that the encode method includes more than simply the code table information, with several code methods being available. Significantly, Figure 10 *does not* refer to multiple Hoffman tables. Indeed, it is difficult to imagine how multiple tables could be utilized if a single table is defined in the ultimate compressed data train. Similarly, Figure 9 is a flow chart that represents the actual encoding process. At step S80, clearly, a single Huffman table is used. That is, even though multiple blocks may be encoded, as indicated by the loop from step S84 returning to step S81, this sequential encoding of multiple blocks *does not* include redefinition or use of other tables. Accordingly, nothing in the reference would teach or suggest that multiple different tables could or should be used for encoding the different subregions. The tables referred to by the Examiner and by the reference itself appear simply to be candidate tables to be considered in conjunction with the different block sizes available for encoding.

Similarly, in the alternative embodiments taught by Hirabayashi et al., a single table is again utilized. For example, as clearly described in column 9, lines 54-59, a Huffman encoder 109 prepares "a presumably optimum Huffman table." The resulting data, as illustrated in Figure 13, includes a single block entitled "Huffman Table." The block *is not* entitled "Huffman Tables." While it appears that this embodiment permits multiple difference mode techniques to be used, as indicated by the difference mode information, this flexibility does not extend to the use of multiple Huffman tables. Again, a single table is employed. In text, the reference simply states that "in this operation, *the Huffman table* prepared in the difference frequency counter 107 is attached to each image frame for use in the decoding operation." See column 10, lines 6-9 (emphasis added). Note once again no reference is made to the actual use of multiple tables for the encoding process.

In the final embodiment, an optimal Huffman table is generated, but here again a single table is used for encoding. The flow chart of Figure 14 clearly relates to the development of a single Huffman table and the resulting data file illustrated in Figure 15, as before, calls for a single Huffman table.

Based upon this analysis, it is respectfully submitted that the Hirabayashi et al. reference does not disclose the use of multiple code tables for encoding an image.

Request Withdrawal of Rejection of Claim 1

In view of these omitted features, the Hirabayashi reference cannot anticipate the pending claim. For these reasons, Appellants respectfully request withdrawal of the foregoing rejection of claim 1 under 35 U.S.C. 102(e) as anticipated by the Hirabayashi reference.

GROUP IV: Independent Claim 24 and Dependent Claims 25-27

Claims

In view of the foregoing legal precedent and summary of problems and solutions provided by the present application, independent claim 24 recites:

> A computer program for compressing image data, the program comprising:
> a machine readable medium; and
> configuration code and a plurality of compression code tables stored on the machine readable medium, the configuration code including an algorithm for analyzing an image data stream, for *compressing subregions of the image data stream by application of a plurality of compression code tables*, and for compiling the compressed subregions into a lossless compressed data file.

Again, claim 24 is clearly directed toward *lossless data compression* using *multiple* compression code *tables* to compress *subregions* of the image data stream. In context of the claim as a whole, the multiple compression code tables are clearly applied to the different *subregions* (not the entire image) of the image data stream. Moreover, the multiple compression code tables are *not merely used to evaluate differences in an image* (i.e., pixel to pixel variances), because the foregoing claim recites that the multiple compression code tables are all applied to *compress the subregions*. Clearly, the claim recites that *a plurality of compression code tables apply to the subregions* of the image data stream for *lossless* data compression. Appellants also reiterate that the claim features, including the plurality of compression code tables applied to the subregions, must be interpreted reasonably and consistently within the scope of the specification and within the understanding of one of ordinary skill in the art. *See In re Prater*, 415 F.2d 1393, 1404-05 (C.C.P.A. 1969).

For these reasons, Appellants stress that claim 24 cannot be anticipated absent a disclosure of *more than one* compression code table *applied to subregions* of the image data stream for compression of those subregions. Accordingly, if the prior art discloses *only one* compression table actually applied to the subregions for compression of those subregions, then the prior art cannot anticipate the present claims.

Omitted Features

As discussed in detail above, Appellants respectfully assert that the Hirabayashi reference does not disclose all of the claimed features, such as the application of multiple compression code tables to subregions of image data. The cited reference absolutely fails to teach or even suggest the use of *multiple* code tables *for actually encoding an overall image*, much less encoding the overall image by applying a plurality of code tables to subregions of image data. Rather, multiple tables are employed by Hirabayashi et al. as *starting points for evaluating* to what level an image should be subdivided for optimal compression. *See* Hirabayashi, Col. 9, lines 7-59.

Referring specifically to the reference, several variants of a basic compression method are described. In the first, and more generic form, sets of reference Huffman tables are starting points for a compression of blocks of different sizes, such as from 4-pixel square blocks to 128-pixel square blocks. The procedure proceeds through the subdivision of an image into these various block sizes. Code tables are then applied to the blocks to determine statistics relating to the compression characteristics obtainable through both the block division and the use of the compression tables. The tables are, in fact, redefined in real time during the process, with the reference tables merely serving as starting points for the eventual encoding that will take place. *See* Hirabayashi Col. 7, lines 38-57.

However, the foregoing code tables never serve, together or alone, for encoding the actual image. Rather, one reading the reference would most reasonably conclude that a *single table* is ultimately selected for *encoding* the various blocks, with the candidate tables merely serving as options for the eventual encoding, in connection with the appropriate selection of the block sizes. *See* Hirabayashi Col. 9, lines 54-59.

In column 8, lines 13-16 of the reference, for example, reference is made to Figure 10 which is said to represent a train of encoded data resulting from the process. As clearly seen in Figure 10, the entire image, referred to in the figure as "one image" includes optimal Huffman table data as a first portion of the string, followed by reference information, which itself includes the block division information and the encode method. It should be noted that the encode method includes more than simply the code table information, with several code methods being available. Significantly, Figure 10 *does not* refer to multiple Hoffman tables. Indeed, it is difficult to imagine how multiple tables could be utilized if a single table is defined in the ultimate compressed data train. Similarly, Figure 9 is a flow chart that represents the actual encoding process. At step S80, clearly, a single Huffman table is used. That is, even though multiple blocks may be encoded, as indicated by the loop from step S84 returning to step S81, this sequential encoding of multiple blocks *does not* include redefinition or use of other tables. Accordingly, nothing in the reference would teach or suggest that multiple different tables

could or should be used for encoding the different subregions. The tables referred to by the Examiner and by the reference itself appear simply to be candidate tables to be considered in conjunction with the different block sizes available for encoding.

Similarly, in the alternative embodiments taught by Hirabayashi et al., a *single table* is again utilized. For example, as clearly described in column 9, lines 54-59, a Huffman encoder 109 prepares "a presumably optimum Huffman table." The resulting data, as illustrated in Figure 13, includes a single block entitled "Huffman Table." The block *is not* entitled "Huffman Tables." While it appears that this embodiment permits multiple difference mode techniques to be used, as indicated by the difference mode information, this flexibility does not extend to the use of multiple Huffman tables. Again, a single table is employed. In text, the reference simply states that "in this operation, *the Huffman table* prepared in the difference frequency counter 107 is attached to each image frame for use in the decoding operation." See column 10, lines 6-9 (emphasis added). Note once again no reference is made to the actual use of multiple tables for the encoding process.

In the final embodiment, an optimal Huffman table is generated, but here again a *single table* is used for *encoding*. The flow chart of Figure 14 clearly relates to the development of a single Huffman table and the resulting data file illustrated in Figure 15, as before, calls for a single Huffman table.

Based upon this analysis, it is respectfully submitted that the Hirabayashi et al. reference does not disclose the use of multiple code tables for encoding an image.

Request Withdrawal of Rejection of Claims 24-27

In view of these omitted features, the Hirabayashi reference cannot anticipate the pending claims. For these reasons, Appellants respectfully request withdrawal of the foregoing rejection of claims 24-27 under 35 U.S.C. 102(e) as anticipated by the Hirabayashi reference.

Issue No. 2

In the Final Office Action, the Examiner rejected independent claim 18 and dependent claims 19-23 under 35 U.S.C. 102(e) as anticipated by the Puri reference. Appellants traverse these rejections and request the Board withdraw the outstanding rejections in view of the foregoing legal precedent and the following remarks.

GROUP III: Independent Claim 18 and Dependent Claims 19-23

Claims

In view of the foregoing legal precedent and summary of problems and solutions provided by the present application, independent claim 18 recites:

> A system for storing, transmitting and viewing images, the system comprising:
> a data compression station configured to store a plurality of compression code tables for conversion of image data to lossless compressed image data and to execute a compression routine in which an image data stream is converted to a compressed file by dividing into subregions and *each subregion compressing in accordance with a compression code table selected from the plurality of compression code tables* based upon which compression code table provides optimal lossless compression of the subregion;
> a data storage device for receiving and storing the compressed file; and
> an image decompression station configured to store the plurality of compression code tables, to access the compressed file from the data storage device, and to execute a decompression routine in which the compression code tables applied to compress the image data stream are applied to decompress the compressed file to reconstruct the image data stream..

Here again, claim 18 is clearly directed toward *lossless data compression* using one of a *plurality of compression code tables* to compress *subregions* of an image data stream. In context of the claim as a whole, the compression code tables are clearly applied to the different *subregions* (not the entire image) of the image data stream. Accordingly, multiple compression code tables are *not merely used to evaluate differences* in an image (i.e., pixel to pixel variances), because the foregoing claim recites that the multiple tables actually apply to the subregions for compression. Appellants also emphasize that the claim features, including the multiple compression code tables applied to the subregions of image data, must be interpreted reasonably and consistently within the scope of the specification and within the understanding of one of ordinary skill in the art. *See In re Prater*, 415 F.2d 1393, 1404-05 (C.C.P.A. 1969).

For these reasons, Appellants stress that claim 18 cannot be anticipated absent a disclosure of *more than one* compression code table *applied to subregions* of the image data stream for compression of those subregions. Accordingly, if the prior art discloses *only one* compression table actually applied to the subregions for compression of those subregions, then the prior art cannot anticipate the present claims.

Omitted Features

Appellants respectfully assert that the Puri reference does not disclose all of the claimed features, such as the application of *multiple* code tables to compress subregions of *image data* into *lossless* compressed data.

First, the Puri reference does not disclose compression of image data, as recited in the instant claim. In the rejection, the Examiner asserted that the Discrete Cosine Transform (DCT) events in Puri represent image data. *See* Paper 7, Page 6. Further, the Examiner admitted that the Puri reference teaches that variable length encoding tables are applied to *DCT events* to compress/encode using encoder 915. *See id.* However, in contrast to the Examiner's reading of these DCT events, the Puri reference describes the DCT events as the output of a transform encoder that are quantized to form coefficients. *See* Puri, col. 1, lines 46-52; col. 3, lines 4-6 and lines 39-46. The DCT events are actually *encoded DCT coefficients* that have been further quantized. The quantization of the image decreases the number of bits needed to store an image by reducing the precision of the image. As a result, the <u>DCT events are not equivalent to image data</u>, because the original image data is lost and only a less precise version is represented by the DCT events. Accordingly, in view of the fact that the Puri reference quantizes the DCT coefficients rather than the image data, the Puri reference cannot disclose the recited feature.

Second, the Puri reference fails to disclose "optimal *<u>lossless</u>* compression of the subregion," as recited in claim 18. In the Puri reference, the DCT coefficients are quantized, which decreases the number of bits needed to store an image by <u>reducing the precision of the image</u>. *See* Puri, col. 5, lines 34-38; col. 7, lines 4-15. The quantization process is a *<u>lossy compression</u>* (not lossless) process that reduces the bits needed through a many to one mapping. As one skilled in the art would recognize, the quantization of the DCT coefficients results in a lossy compression process, as illustrated by the definitions provided in the attached Exhibit A. Specifically, the exhibit includes three pages of definitions regarding various compression techniques found at the time of preparation of the present response at the URL, http://my.engr.ucdavis.edu/~ssaha/glossary.html. Appellants submit that these definitions reflect the understanding of one skilled in the art. Thus, as a result of quantizing the DCT coefficients, the Puri reference cannot disclose a lossless compression of the image. Thus, the Puri reference does not disclose the recited feature of "providing lossless compression of the subregion," as recited in claim 18.

Request Withdrawal of Rejection of Claims 18-23

Because the Puri reference fails to disclose *all* of the claimed elements, the reference cannot anticipate the claimed subject matter. Therefore, independent claim 18 and dependent claims 19-23 are believed to be patentable over the Puri reference. For these reasons, Appellants respectfully request withdrawal of the foregoing rejection of claims 18-23 under 35 U.S.C. 102(e) as anticipated by the Puri reference.

Issue No. 3:

In the Final Office Action, the Examiner rejected independent claim 12 and dependent claims 2-11 and 13-17 under 35 U.S.C. 103(a) as obvious over Hirabayashi in view of Puri. Appellants traverse these rejections and request the Board withdraw the outstanding rejections for the reasons set forth below the following legal precedent.

Legal Precedent

First, regarding claim interpretation, the claims must be given their broadest reasonable interpretation consistent with the specification and the interpretation that those skilled in the art would reach. *See In re Prater*, 415 F.2d 1393, 1404-05, 162 U.S.P.Q. 541, 550-51 (C.C.P.A. 1969); *In re Cortright*, 165 F.3d 1353, 1359, 49 U.S.P.Q.2d 1464, 1468 (Fed. Cir. 1999).

Second, regarding obviousness, the burden of establishing a *prima facie* case of obviousness falls on the Examiner. *Ex parte Wolters and Kuypers*, 214 U.S.P.Q. 735 (PTO Bd. App. 1979). The Examiner must provide objective evidence, rather than subjective belief and unknown authority, of the requisite motivation or suggestion to combine or modify the cited references. *In re Lee*, 61 U.S.P.Q.2d. 1430 (Fed. Cir. 2002). Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention absent some teaching or suggestion supporting the combination. *ACS Hospital Systems, Inc. v. Montefiore Hospital*, 732 F.2d 1572, 1577, 221 U.S.P.Q. 929, 933 (Fed. Cir. 1984). Accordingly, to establish a *prima facie* case, the Examiner must not only show that the combination includes *all* of the claimed elements, but also a convincing line of reason as to why one of ordinary skill in the art would have found the claimed invention to have been obvious in light of the teachings of the references. *Ex parte Clapp*, 227 U.S.P.Q. 972 (B.P.A.I. 1985). The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d. 1430 (Fed. Cir. 1990). Moreover, a statement that the proposed modification would have been "'well within the ordinary skill of the art'" based on individual knowledge of the claimed elements cannot be relied upon to establish a *prima facie* case of obviousness without some *objective reason to combine* the teachings of the references. *Ex parte Levengood*, 28 U.S.P.Q.2d 1300 (Bd. Pat. App. & Inter. 1993); *In re Kotzab*, 217 F.3d 1365, 1371, 55 U.S.P.Q.2d. 1313, 1318 (Fed. Cir. 2000); *Al-Site Corp. v. VSI Int'l Inc.*, 174 F.3d 1308, 50 U.S.P.Q.2d. 1161 (Fed. Cir. 1999). When prior art references require a selected combination to render obvious a subsequent invention, there must be some reason for the combination other than the hindsight gained from the invention itself, i.e., something in the prior art as a whole must suggest the desirability, and thus the obviousness, of making the combination. *Uniroyal Inc. v. Rudkin-Wiley Corp.*, 837 F.2d 1044, 5 U.S.P.Q.2d 1434 (Fed. Cir. 1988). One cannot use hindsight reconstruction to pick and choose among isolated

disclosures in the prior art to deprecate the claimed invention. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988).

Third, it is improper to combine references where the references teach away from their combination. *In re Grasselli*, 713 F.2d 731, 743, 218 U.S.P.Q. 769, 779 (Fed. Cir. 1983); M.P.E.P. § 2145. Moreover, if the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious. *In re Ratti*, 270 F.2d 810, 123 U.S.P.Q. 349 (C.C.P.A. 1959); see M.P.E.P. § 2143.01.

Fourth, regarding the theory of inherency, the extrinsic evidence must make clear that the missing descriptive matter is *necessarily* present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. *In re Robertson,* 169 F.3d 743, 49 U.S.P.Q.2d 1949 (Fed. Cir. 1999) (Emphasis Added). The mere fact that a certain thing *may* result from a given set of circumstances is not sufficient. *Id.*

GROUP II: Independent Claim 12 and Dependent Claims 13-17

Claims

In view of the foregoing legal precedent and summary of problems and solutions provided by the present application, independent claim 12 recites:

> A method for compressing image data, the method comprising the step of:
> (a) defining a family of compression code tables for converting uncompressed image data to *lossless compressed data*;
> (b) storing the compression code tables in an image data compression station and in an image data decompression station;
> (c) selecting *at least two of the compression code tables for compression of subregions of an image data stream*;
> (d) compressing the image data stream in accordance with the selected compression code tables at the compression station for decompression at the decompression station.

Here again, claim 12 is clearly directed toward *lossless data compression* using <u>at least two compression code tables</u> to compress <u>*subregions*</u> of an image data stream. In context of the claim as a whole, the compression code tables are clearly applied to the different *subregions* (not the entire image) of the image data stream. Accordingly, multiple compression code tables are *not merely used to evaluate differences* in an image (i.e., pixel to pixel variances), because the foregoing claim recites that the <u>multiple tables actually apply to the subregions</u> for compression. Appellants also emphasize that the claim features, including the multiple compression code tables applied to the subregions of image data, must be interpreted reasonably and consistently within the scope of the

specification and within the understanding of one of ordinary skill in the art. *See In re Prater*, 415 F.2d 1393, 1404-05 (C.C.P.A. 1969).

For these reasons, Appellants stress that claim 12 cannot be obvious over the cited references absent a disclosure of *more than one* compression code table *applied to subregions of the image data* stream for *lossless compression* of those subregions. Accordingly, if the prior art discloses *only one* compression table actually applied to the subregions for compression of those subregions, then the prior art cannot render the present claims obvious.

Omitted Features

Appellants contend that the Hirabayashi and the Puri references fail to disclose all of the recited features of the claims.

First, the cited references each have deficiencies, which are not obviated by the remaining reference. As discussed above, the Hirabayashi reference fails to disclose multiple tables applied to the subregions of image data for compression of those subregions. Puri fails to obviate the deficiencies of Hirabayashi, because Puri does not teach application of the tables to image data. Instead, Puri discloses the compression of DCT events, which are not image data.

Second, the Hirabayashi reference and the Puri reference, alone or in the proposed combination, fail to disclose "storing the compression code tables in an image data compression station and in an image data decompression station." In the rejection, the Examiner admitted that the Hirabayashi reference does not explicitly teach storing compression/encoding tables in the image data compression/encoding station. The Examiner asserted that this feature is taught by Puri. As discussed above, the Hirabayashi reference teaches creating an optimal Huffman table that is used to encode the image. The table cannot be stored at another station, because the Huffman table used to encode the image is not created prior to the image being processed. As a result, the created table must be transmitted with the image for the image to be decompressed.

The Puri reference fails to cure the deficiencies in the Hirabayashi et al. reference with regard to the recited feature. Again, as previously discussed, the Puri reference teaches encoding the quantized DCT events of an image. The Puri reference fails to disclose the recited feature because the quantized DCT events are not equivalent to image data. As the quantization process is a *lossy* compression process, it reduces the original image through a many to one mapping. From this compressed data the original image can only be recreated as a less precise version. By quantizing the DCT coefficients, the Puri reference cannot disclose *storing compression code tables* that are utilized in *lossless compression*, because quantization implies lossy compression.

See exhibit. Furthermore, the tables in the Puri reference are utilized to encode quantized DCT events, which is not equivalent to image data. Thus, the Puri reference fails to disclose or teach *storing compression code tables*. Accordingly, the Hirabayashi et al. and the Puri references fail to disclose or teach "storing the compression code tables in an image data compression station and in an image data decompression station" as recited in claim 12.

No Suggestion or Motivation to Combine

In addition, even if the references included all of the claimed elements, the Examiner has failed to provide objective evidence of the requisite suggestion or motivation to combine the cited references. To the contrary, the references are actually directed to different methods of encoding that handle the original image in completely different manners. The Hirabayashi et al. and Puri references actually teach handling the compression tables in different manners that are not compatible with each other. Given the disclosures and teachings of the respective references, the combination of Hirabayashi et al. and the Puri references is improper, because the proposed combination would render each reference <u>inoperable for its intended purpose</u> and it would <u>change the principle of operation</u> of each respective reference.

In the present case, the references do not support the proposed combination. As discussed above, the Hirabayashi et al. reference is directed to a technique for creating a new Huffman table for encoding the image in step S7. *See* Hirabayashi, col. 7, lines 38-51. The creation of a new table is disclosed as a role of the Huffman encoder 109, which encodes the image. *See* Hirabayashi, col. 9, lines 56-66. To allow another to decompress the encoded image, the prepared table is attached to the image frame to allow the decpompression of the image. *See* Hirabayashi, col. 10, lines 6-9. The encoding of the image in the Hirabayashi reference appears to be *lossless* compression technique that allows the original image to be recreated.

Conversely, the Puri reference is directed to a means of *lossy* compression that alters and is unable to reproduce the original image. The Puri reference teaches *encoding DCT events*, which are not *image data.* In fact, the DCT events are described as the output of a transform encoder that are quantized to form the DCT events. *See* Puri, col. 1, lines 46-52; col. 3, lines 4-6 and lines 39-46. Again, by quantizing the DCT events, the number of bits in the original image is reduced and the precision of the original image is lost. As a result, the DCT events are not equivalent to image data because the DCT events are quantized. The lossy compression technique taught in the Puri reference does not disclose or suggest the lossless compression technique of the Hirabayashi et al. reference. In fact, the two approaches are completely incompatible compression methods that cannot be combined.

Furthermore, each of the references teaches decompressing the images in mutually exclusive and incompatible manners., In the Puri reference, the tables are known and located at a remote encoder for decompression of the DCT events. In contrast, the Hirabayashi et al. reference actually teaches including the prepared Huffman table with the image frame. As discussed above, a Huffman table is created for compressing the image, the table employed being *unique to the image*. The prepared Huffman table has to be included with the compressed image because the system that receives the compressed image may not be able to decompress the image without the prepared Huffman table. Clearly, the methods are completely incompatible because one of references requires the compression table to be sent with the image, while the other reference uses existing tables at the receiving end to process the image. Thus, the Hirabayashi et al. and Puri references actually teach handling the compression tables in different manners that are not compatible with each other. Accordingly, the Hirabayashi et al. and Puri references, alone or in combination, fail to provide a suggestion for the combination.

Because the references fail to disclose *all* of the claimed elements, and cannot be combined as proposed by the Examiner, independent claim 12 and its respective dependent claims are believed to be patentable over Hirabayashi and Puri.

Request Withdrawal of Rejection of Claims 12-17

For these reasons, Appellants respectfully request withdrawal of the foregoing rejection of claims 12-17 under 35 U.S.C. 103.

GROUP I: Dependent Claims 2-11

As discussed in detail above, the primary reference (i.e., Hirabayashi) lacks certain features recited in independent claim 1. For example, the Hirabayashi reference fails to disclose multiple tables applied to subregions of image data. Moreover, as discussed above, the secondary reference (i.e., Puri) fails to obviate the deficiencies of Hirabayashi. Each of the foregoing claims 2-11 depends from independent claim 1 and, thus, are believed to be patentable by way of their dependencies on claim 1 and by way of further features recited in each respective claim. For these reasons, Appellants respectfully request withdrawal of the foregoing rejection of claims 2-11 under 35 U.S.C. 103.

10. APPENDIX OF CLAIMS ON APPEAL

1. (Previously Presented) A method for compressing image data from an uncompressed image data stream, the method comprising the steps of:

(a) compiling and storing a plurality of compression mapping tables for converting uncompressed data representative of individual picture elements to lossless compressed data;

(b) applying at least first and second compression mapping tables from the stored plurality of compression mapping tables to subregions of an uncompressed image data stream to compress the subregions; and

(c) appending data for the compressed subregions to form a compressed image data stream.

2. (Original) The method of claim 1, wherein the compression mapping tables are compression tables mapping a parameter representative of each picture element to a compressed data code.

3. (Original) The method of claim 2, wherein the parameter is a prediction error for each picture element.

4. (Original) The method of claim 3, wherein the prediction errors are identified by application of a desired predictor algorithm to the uncompressed image data stream.

5. (Original) The method of claim 1, including the further step of selecting the compression mapping tables applied in step (b) from the plurality of compression mapping tables.

6. (Original) The method of claim 5, wherein the compression mapping tables are selected based upon relative entropy levels of each subregion.

7. (Original) The method of claim 6, wherein the relative entropy levels are determined by analysis of relative variation of picture element intensity within each subregion.

8. (Original) The method of claim 7, wherein the variation of picture element intensity is determined by application of a prediction algorithm to determine a difference between a predicted value of each picture element and the actual value of the respective picture element.

9. (Original) The method of claim 1, wherein the compression mapping tables employed in step (b) are selected based upon which compression mapping tables provide the shortest compressed data stream for each subregion.

10. (Original) The method of claim 1, wherein the number of compression mapping tables employed in step (b) may be encoded with at most two bits of data.

11. (Original) The method of claim 1, including the step of encoding in the compressed image data stream identifiers representative of the compression mapping tables applied in step (b).

12. (Previously Presented) A method for compressing image data, the method comprising the step of:

(a) defining a family of compression code tables for converting uncompressed image data to lossless compressed data;

(b) storing the compression code tables in an image data compression station and in an image data decompression station;

(c) selecting at least two of the compression code tables for compression of subregions of an image data stream;

(d) compressing the image data stream in accordance with the selected compression code tables at the compression station for decompression at the decompression station.

13. (Original) The method of claim 12, including the step of encoding in the compressed image data stream identifiers of the selected compression code tables.

14. (Original) The method of claim 12, wherein the compression code tables are defined based upon analysis of typical images to be compressed at the compression station.

15. (Original) The method of claim 12, comprising the further step of applying a prediction algorithm to portions of the data stream representative of individual picture elements of an image to determine difference values between predicted values and actual values for the picture elements, and wherein the compression code tables are applied to encode the difference values.

16. (Original) The method of claim 12, wherein the compression code tables selected at step (c) are selected based upon which tables of the family of tables provides the shortest stream of compressed data for each subregion.

17. (Original) The method of claim 12, wherein the number of compression mapping tables employed in step (c) may be encoded with at most two bits of data.

18. (Previously Presented) A system for storing, transmitting and viewing images, the system comprising:

a data compression station configured to store a plurality of compression code tables for conversion of image data to lossless compressed image data and to execute a compression routine in which an image data stream is converted to a compressed file by dividing into subregions and each subregion compressing in accordance with a compression code table selected from the plurality of compression code tables based upon which compression code table provides optimal lossless compression of the subregion;

a data storage device for receiving and storing the compressed file; and

an image decompression station configured to store the plurality of compression code tables, to access the compressed file from the data storage device, and to execute a decompression routine in which the compression code tables applied to compress the image data stream are applied to decompress the compressed file to reconstruct the image data stream.

19. (Original) The system of claim 18, further comprising a compression library for storing at least a portion of the compression and decompression routines, and wherein the compression station and the decompression station can access the compression library for code used in the compression or decompression routines.

20. (Original) The system of claim 18, wherein the compression routine includes analysis of the image data stream for data representative of a characteristic of an image encoded by the image data stream.

21. (Original) The system of claim 20, wherein the characteristic is an identification of an image acquisition system originating the image data stream.

22. (Original) The system of claim 20, wherein the characteristic is an identification of a feature represented in an image encoded by the image data stream.

23. (Original) The system of claim 18, wherein the compression routine includes encoding of identifiers of the selected compression code tables within the compressed file, and wherein the decompression routine includes analysis of the identifiers for selection of the same compression code tables for decompression of the compressed file.

24. (Previously Presented) A computer program for compressing image data, the program comprising:

a machine readable medium; and

configuration code and a plurality of compression code tables stored on the machine readable medium, the configuration code including an algorithm for analyzing an image data stream, for compressing subregions of the image data stream by application of a plurality of compression code tables, and for compiling the compressed subregions into a lossless compressed data file.

25. (Original) The computer program of claim 24, wherein a family of candidate compression code tables is stored on the machine readable medium.

26. (Original) The computer program of claim 24, wherein the algorithm includes computation of compressed data lengths provided by application of a plurality of candidate compression code tables for compression of each subregion, and selection of the compression code tables providing the shortest compressed data lengths for each subregion.

27. (Original) The computer program of claim 24, wherein the code is installed on the machine readable medium via a configurable network link.

9. **CONCLUSION**

In view of the above remarks, Appellants respectfully submit that the Examiner has provided no supportable position or evidence that claims 1-27 are unpatentable under 35 U.S.C. §§ 102 or 103. Accordingly, Appellant respectfully requests that the Board find claims 1-27 patentable over the prior art of record and withdraw all outstanding rejections.

Fees and General Authorization for Extensions of Time

In accordance with 37 C.F.R. § 1.136, Appellants hereby provide a general authorization to treat this and any future reply requiring an extension of time as incorporating a request therefor. Appellants hereby request a one (1) month extension in the statutory period for response from October 29, 2003 to November 29, 2003 in accordance with 37 C.F.R. § 1.136. The Commissioner is authorized to charge the requisite fee of $110.00 for the (1) month extension of time, the requisite fee of $330.00 for this appeal brief, and any additional fees which may be required, to Account No. 50-2401, Order No. 15-IS-5393/YOD (GEMS:0071).

Respectfully submitted,

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Glossary of Terms: Image Data Compression

ISO - International Organization for Standardization
Founded in 1947, ISO is a worldwide federation of national standards bodies from some 130 countries, one from each country, and has almost 200 technical committees. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity. It issues standards on a vast number of subjects, ranging from nuts and bolts to image and video compression systems.

ITU - International Telecommunications Union (formerly **CCITT)**
Formerly known as the Consultative Committee on International Telegraph and Telephones (CCITT), and headquartered in Geneva, Switzerland ITU is an international organization within which governments and the private sector coordinate global telecom networks and services like fax and modems.

IEC - International Electrotechnical Commission
The International Electrotechnical Commission is the international standards and conformity assessment body for all fields of electrotechnology. Founded in 1906, the International Electrotechnical Commission (IEC) is the world organization that prepares and publishes international standards for all electrical, electronic and related technologies. The membership consists of more than 50 participating countries. The IECís mission is to promote, through its members, international cooperation on all questions of electrotechnical standardization and related matters, such as the assessment of conformity to standards, in the fields of electricity, electronics and related technologies.

JPEG - Joint Photographic Experts Group
A highly successful continuous-tone, still-picture coding international standard named after the Joint Photographic Experts Group that developed it. The JPEG standard (IS 10918-1/ITU-T T.81) was originally approved in 1992 and was developed as an official joint project of both the ISO/IEC JTC1 and ITU-T organizations.

JPEG-2000
A future new still-picture coding standard, JPEG-2000 is a joint project of the ITU-T SG8 and ISO/IEC JTC1 SC29 WG1 organizations. It is scheduled for completion late in the year 2000.

MPEG - Motion Pictures Experts Group
A highly successful image-sequence or video coding international standard named after the Motion Pictures Experts Group that developed it. The standard comes in various flavors like MPEG-1, MPEG-2, and MPEG-4 having different features, the main one being the bit rate. The MPEG-1 standard (IS 11172-2) was a project of the ISO/IEC JTC1 organization and was approved in 1993. MPEG-1 codec is capable of approximately videotape quality or better at about 1.5 Mbit/s. MPEG-2 forms the heart of broadcast-quality digital television (DTV). It's a step higher in bit rate, picture quality, and popularity. The MPEG-2 standard (IS 13818-2) was a joint project of the ISO/IEC JTC1 and ITU-T organizations and was completed in 1994. Its

target bit-rate range is approximately 4-30 Mbit/s. MPEG-4 is currently under development.

Lossless and Lossy Image Compression

In lossless compression, the reconstructed image after compression is numerically identical to the original image on a pixel-by-pixel basis. However, only a modest amount of compression is achievable in this technique. In lossy compression, on the other hand, the reconstructed image contains degradation relative to the original, because redundant information is discarded during compression. As a result, much higher compression is achievable, and under normal viewing conditions, no visible loss is perceived (visually lossless).

Predictive and Transform coding

In predictive coding, information already sent or available is used to predict future values, and the difference is coded. Since this is done in the image data or spatial domain, it is relatively simple to implement and is readily adapted to local image characteristics. Differential Pulse Code Modulation (DPCM) is one particular example of predictive coding. Transform coding, on the other hand, first transforms the image from its spatial domain representation to a different type of representation using some well-known transform like DCT and then codes the transformed values (coefficients). This method provides greater data compression compared to predictive methods, although at the expense of greater computations.

DCT - Discrete Cosine Transform

The DCT can be regarded as a discrete-time version of the Fourier-Cosine series. It is a close relative of DFT - a technique for converting a signal into elementary frequency components, and thus DCT can be computed with a Fast Fourier Transform (FFT) like algorithm in *O(n log n)* operations. Unlike DFT, DCT is real-valued and provides a better approximation of a signal with fewer coefficients. The DCT of a discrete signal *x(n), n=0, 1, .. , N-1* is defined as,

$$X(u) = \sqrt{\frac{2}{N}}\, C(u) \sum_{n=0}^{N-1} x(n) \cos\left(\frac{(2n+1)u\pi}{2N}\right)$$

where, $C(u) = 0.707$ for $u = 0$ and
$= 1$ otherwise.

DCT is very popular and used extensively in current image compression algorithms and standard.

DWT - Discrete Wavelet Transform

Wavelets are functions defined over a finite interval and having an average value of zero. The basic idea of wavelet transform is to represent any arbitrary function *É(t)* as a superposition of a set of such wavelets or basis functions. These basis functions or ëbaby waveletsí are obtained from a single prototype wavelet called the ëmother waveletí, by dilations or contractions (scaling) and translations (shifts). The Discrete Wavelet Transform of a finite length signal *x(n)* having *N* components for example, is expressed by an *N* by *N* matrix.

Quantization

Quantization is simply the process of decreasing the number of bits needed to store a set of values (transformed coefficients, in the context of data compression) by reducing the precision of

those values. Since quantization is a many-to-one mapping, it's a lossy process and is the main source of compression in a lossy image coding scheme. Quantization can be performed on each individual coefficient, which is known as *Scalar Quantization (SQ)*. Quantization can also be performed on a group of coefficients together, and this is known as *Vector Quantization (VQ)*. Both, uniform and non-uniform quantizers can be used depending on the problem at hand.

Entropy Encoder

An entropy encoder uses a model to accurately determine the probabilities for each input data value and produces an appropriate code based on these probabilities so that the resultant output code stream will be smaller than the input stream. In image coders an entropy encoder further compresses the quantized/predicted values losslessly to give better overall compression. Most commonly used entropy encoders are the *Huffman encoder* and the *arithmetic encoder,* although for applications requiring fast execution, simple run-length encoding (RLE) has proven very effective.

PSNR - Peak Signal-to-Noise Ratio

This is a quantitative measure of a lossy image coder.

$$\text{PSNR} = 10\log_{10}\left(\frac{P^2}{D}\right) = 10\log_{10}\left(\frac{255}{MSE}\right) \text{ dB, for an 8-bit image.}$$

MSE - Mean Square Error

This is the quantitative measure of error between the original and reconstructed images.

$$\text{MSE} = \frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}|x(m,n) - \breve{x}(m,n)|^2$$